EE 506 – Digital Control  
University of North Dakota  
Fall 2015

Instructor: Dr. Arash Nejadpak  
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Office Hours: Monday and Wednesday 9:00AM – 11:00AM and by appointment

Days and Times: Mon, Wed, Fri 11:00AM – 11:45AM; Harrington Hall, Room 108

Prerequisite: EE 405 – Control System I

Prerequisite by topic: Evaluation of system response, Mason’s Gain Formula, Stability discussion using Routh-Hurwitz criterion, Root-Locus, Nyquist criterion,

Required Materials:  
Textbook: Discrete-Time Control Systems, 2nd Edition  
Authors: Katsuhiko Ogata  
Publisher: Prentice Hall

Access to Simulator software – Homework assignments will be completed using Matlab/Simulink, which can be accessed through Citrix.

Tutorial assistance and a number of other study aids are included:


All types of calculators are authorized.
Access to Blackboard

Course Description:

This course is designed to introduce the student to the digital system representation, analysis and simulation; Z-Transform; digital controller design and realization; Microprocessor based controller, etc. At the end of the course, the students should:

- Understand the idea behind digital control as compared to analog control. [Program Outcome (a)]
- Do simulation diagram and model systems in discrete state variable forms. [Program Outcome (c)]
- Model and solve discrete state variable equations using discrete Z-domain. [Program Outcome (b)]
- Evaluate discrete time open loop system transfer function with data hold transfer function included. [Program Outcome (e)]
- Compute discrete system time response for open or closed loop systems for first, second or higher order systems. [Program Outcome (k)]

Learning Objectives:

1. Discrete time system and Z-transform. System difference equation, simulation diagram, state variable equations and solution.
2. Sampling and reconstruction. Ideal sampler, and other samplers. Starred transform, A/D and D/A conversion.
3. Open loop discrete time systems.
4. Closed loop discrete time systems.
5. System time response characteristics.
7. Frequency response.

Course Goals:

By the end of the course the students should be able to:

- Apply the knowledge of mathematics and engineering tools to analyze, design and testing of the system.
- Design a system, components, or process to meet desired needs within realistic constraints.
- Identify, formulate, and solve engineering problems.
- Apply engineering tools such as MATLAB/Simulink, to design and simulation of the digital system.

Relationship of Course to Program Outcomes:

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<tr>
<th>Program Outcomes</th>
<th>Relationship</th>
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<tbody>
<tr>
<td>(a): Apply knowledge of math, engineering, and science</td>
<td>Significant</td>
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<tr>
<td>(b): Design and conduct experiments, as well as to analyze and interpret data</td>
<td>Significant</td>
</tr>
<tr>
<td>(c): Design a system, component, or process to meet desired needs within realistic constraints</td>
<td>Significant</td>
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<tr>
<td>(d): Function on multi-disciplinary teams</td>
<td>None</td>
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<tr>
<td>(e): Identify, formulate, and solve engineering problems.</td>
<td>Significant</td>
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<tr>
<td>(f): Understand professional and ethical responsibility</td>
<td>None</td>
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<td>(g): Communicate effectively</td>
<td>None</td>
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<td>(h): Understand the impact of engineering solutions in a global, economic, environmental, and societal context</td>
<td>None</td>
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<tr>
<td>(i): Recognition of the need for, and an ability to engage in life-long learning</td>
<td>None</td>
</tr>
<tr>
<td>(k): Use techniques, skills, and tools in engineering practice.</td>
<td>Significant</td>
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**Class Structure:**

Class sessions will combine lecture, discussion, and problem solving. Some textbook problems will be used, so you will want to bring your textbook to class. You will also want to have a calculator with you. During most class sessions you will have an opportunity to solve problems on your own or in a small group to which you will be assigned. These problems are intended to enhance your understanding of the material, help you work through homework assignments, and provide examples of potential exam questions.

**Expectations:**

Students are expected to attend this course regularly, to make their best attempt to arrive at each class meeting on time, and to stay until the class is completed. Leaving class early, or leaving and returning to class, is disruptive and highly discouraged. Class attendance helps the student acquire knowledge and clarification. Material will be covered in class that may not be covered in the textbook. If you are not present, you are still responsible for all material covered and any changes that may have been made in assignments. Pertinent readings should be completed prior to class and you should come to class prepared for discussion. Reading in advance of class will enhance your ability to participate in class discussions and to benefit from in-class exercises. Out of courtesy to your fellow students, all cell phones, pagers, and electronic devices should be turned off or set to vibrate mode prior to class. **Text messaging during class is not permitted.** Violation of these policies will adversely impact your grade.

**Power-point Slides for Class Lectures:**

The slides include data for some examples that will be used to illustrate important concepts. You should find that your learning experience is enhanced by having a copy of the slides with you in class and it is your responsibility to download and print these documents.

**Group Projects:**

You will be randomly assigned to a group and will work with that group throughout the term. Each group will turn in one “solution” and all group members who were present or participated will receive the same grade for that assignment. Only one submission will be accepted per group and each individual should write his/her name on the joint submission. The purpose of the group project is to help all students learn the material. If you are confident that you understand how to do a particular problem, help your fellow group members to understand it as well. Similarly, if you don’t understand how to do something on a group assignment, ask for help.
Homework Problems:
Homework problems will be completed and graded through Blackboard. Completion and understanding of the assigned problems are critical for you to successfully complete this course. Problems must be completed by the due date and no late or manual submissions will be accepted.

Examinations:
There will be two interim exam and a cumulative final exam. The interim exam will be given at the beginning of class and will last about 1 hour. If you arrive late for an exam, extra time will not be given. Exams will comprise problems similar in format to homework problems and class examples, conceptual questions, and questions/problems that require you to apply concepts to contexts similar (but not exactly the same) to the materials covered in class or in the homework problems. Students are allowed to use 1 page notes to remind the complicated formulas or algorithms during any exam. All different types of calculators are allowed. Pen/pencils, and erasers are the only materials you may use during exams. Cell phones, PDAs, etc. will not be permitted as calculators or clock-substitutes during exams. If an examination is to be missed, the student must inform the instructor prior to the exam. The instructor will decide, based on the evidence provided, whether or not an absence is excused. Make-up exams will be permitted only in truly exceptional circumstances and generally only when prior arrangements have been made with the instructor. MAKE-UP EXAMS WILL NOT BE GIVEN WITHOUT PRIOR APPROVAL AND APPROPRIATE WRITTEN DOCUMENTATION. A COMMON MAKE-UP DATE MAY BE REQUIRED IF MULTIPLE STUDENTS HAVE EXCUSED ABSENCES.

Grading:
The following weights will be applied in the calculation of each student’s course grade:

<table>
<thead>
<tr>
<th>Component</th>
<th>Weight</th>
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<tbody>
<tr>
<td>Exam 1</td>
<td>15%</td>
</tr>
<tr>
<td>Exam 2</td>
<td>15%</td>
</tr>
<tr>
<td>Final Exam</td>
<td>40%</td>
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<tr>
<td>Homework</td>
<td>10%</td>
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<tr>
<td>*Project</td>
<td>20%</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
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Course averages will be translated into letter grades according to the following table:

- 90-100 A
- 75-89 B
- 60-74 C
- 50-59 D
- < 49 F

At the end of the semester, any necessary adjustments will be made to reflect the above allocation of points. Blackboard will not be altered to reflect these adjustments.

Extra Credit Problems, Projects, or Assignments:
There may not be extra credit problems, projects, or assignments. If you have concerns regarding your grade, please see me to determine what you need to do in order to improve your performance. **Do not wait until the end of the semester to do this. Come to me early to enable us to develop a plan for your successful completion of this class.**

**Study Suggestions:**
- There is a lot of material to cover in this course. I strongly recommend that you do not delay in studying for this course. Work hard from the start.
- Attend class, come prepared, and ask questions.
- I will not be able to cover everything in the class lecture, so reading the chapter and completing the exercises/problems will enhance your understanding of the material.
- There is no substitute for working through the homework assignments.
- Prepare well for each exam, be able to apply principles in varied settings, and avoid memorizing. **Do not** wait until the night before an exam to study.

**Communication:**

I will communicate with you periodically through Blackboard. E-mail sent in this fashion is delivered to your UND e-mail address. If you have specified another e-mail account to which your UND e-mail will be forwarded, please ensure that it is accurate and that you are receiving e-mails promptly. If a message I send bounces, I cannot easily determine if your UND account or alternate account has rejected the message. Therefore, it is essential that you maintain your e-mail account so that communication lines are operating properly. Students are responsible if they do not receive or review e-mail from the instructor in a timely manner. Also, when sending e-mail please be sure to identify the course you are communicating about and your name since the return e-mail address does not always readily identify you. I will be unable to respond to questions or issues raised in e-mail messages unless I know with whom I am communicating.
Important Dates:

August 25: First day of the Class
September 2: Last day to add course or drop without record
September 7, November 11: Holiday.
Friday, April 10: Last day to withdraw from term or drop with record
Wednesday, December 16: Final Exam (10:15 AM)

A withdrawal grade does not affect your GPA but does appear on your official transcript.

Chapters and Topics:

Week 1 Introduction: real-time control, theory, design, and implementation
Week 2 Review of the z-transform
Week 3 Sampling and reconstruction of signals: A/D conversions, PWM.
Week 4 Z-plane analysis of discrete-time control systems
Week 5 Realization and implementation of digital controllers/filters
Week 6 Exam 1
Week 7, 8 Practical aspects of real-time control implementation: fixed- vs floating-point, quantization effects, truncation and round-off effects, sampling rate selection, scaling for DSPs
Week 9, 10 Analysis and design in the frequency domain: relation to time-domain characteristics, performance specs, stability, PID design and implementation issues
Week 11 State-space analysis: state-space representation, Lyapunov stability
Week 12 Exam 2
Week 13, 14 Design and implementation of real-time controllers, simulators, and hardware design
Week 15 Project Presentation

Note: The above topical outline represents the broad course structure. Based on our progress during the semester, further materials may be added or some may be deleted at the instructor’s discretion. This schedule is subject to change.
Academic Honesty:

We expect complete academic honesty as specified by the University of North Dakota Code of Student Life. We expect all students to be aware of these issues and the possible consequences. Students will receive no credit for any assignment/exam completed under the context of scholastic dishonesty. Additionally, other disciplinary actions may be taken, including but not limited to suspension from the University. A written record of any scholastic dishonesty will be kept in the student's academic file housed in the Department of Electrical Engineering.

As stated on the Registrar’s website:

Students are expected to maintain scholastic honesty. Scholastic dishonesty includes but is not limited to cheating on a test, plagiarism, and collusion.

A. Cheating on a test includes, but is not restricted to:
   • Copying from another’s test.
   • Processing or using material during a test not authorized by the person giving the test.
   • Collaborating with or seeking aid from another student during a test without authority.
   • Knowingly using, buying, selling, stealing, transporting, or soliciting in whole or in part the contents of an unadministered test.
   • Substituting for another student or permitting another student to substitute for oneself to take a test.
   • Bribing another person to obtain an unadministered test or information about an unadministered test.
   • Last but not least: The 2nd paragraph under “Important Notes”

B. Plagiarism means the appropriation, buying, receiving as a gift, or obtaining by any means another person’s work and the unacknowledged submission or incorporation of it in one’s own work. This includes appropriation of another person’s work by the use of computers or any electronic means.

C. Collusion means the unauthorized collaboration with another person in preparing written work offered for credit.

For detailed policy statements and procedures dealing with scholastic dishonesty, see the Code of Student Life, Appendix IIIa, at:

Students with Disabilities

If you have emergency medical information to share with the instructor, if you need special
arrangements in case the building must be evacuated, or if you need accommodations in this course because of a disability, please make an appointment with me. My office location and contact information are given in this syllabus.

The following is UND’s Policy. UND recognizes its responsibility for making reasonable accommodations/adjustments to ensure there is no discrimination on the basis of disability, as established under Section 504 of the Rehabilitation Act and the Americans with Disabilities Act. Disability Services for Students (DSS) assists students by arranging disability accommodations, collaborating with faculty on providing accommodations, and consulting with UND personnel about making all UND programs and services accessible. Students planning to use accommodations register with DSS and submit current documentation of disability. DSS will verify their eligibility and identify the accommodations they will be authorized to use on a semester by semester basis. For more information, contact DSS located at 190 McCannel Hall, Phone: (701)-777-3425, or check the DSS web site for more details and procedures at: http://www.und.edu/dept/dss/.

Note: In matters not explicitly covered in this syllabus, the established policies of the Department of Electrical Engineering and University of North Dakota will be followed.